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FINAL REPORT

to the

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On the

1993 GORDON RESEARCH CONFERENCE ON

THE PHYSICS AND CHEMISTRY OF LASER DIAGNOSTICS IN COMBUSTION

Held at Plymouth State College, Plymouth, NH

July 12-16, 1993

Submitted by

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Conference Chairman

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CONTENTS

1993 GORDON RESEARCH CONFERENCE
ON
THE PHYSICS AND CHEMISTRY OF LASER DIAGNOSTICS IN COMBUSTION

INTRODUCTION

The 1993 Gordon Research Conference on the Physics and Chemistry of Laser Diagnostics in Combustion was held at Plymouth State College (South) in Plymouth, New Hampshire, July 12-16, 1993. This conference is primarily concerned with the fundamental physics and chemistry underlying the wide variety of laser-based optical spectroscopic diagnostic techniques which are used for studying combustion processes. The focus is on in-situ and nonperturbing optical methods for one-, two-, and three-dimensional measurements of species concentrations, temperature, and velocity. The development of such quantitative methods using linear and nonlinear optical interactions encompasses a broad scope of interdisciplinary research including basic and applied physics and chemistry.

This was the seventh time this Gordon Research Conference has convened on a biennial basis. The conference has played an important role in the development of combustion diagnostics and has become the primary meeting of this international research community. The previous conferences have been chaired by John Daily (University of Colorado) in 1981, David Crosley (SRI International) in 1983, Alan Eckbreth (United Technologies) in 1985, Ronald Hanson (Stanford University) in 1987, Richard Chang (Yale University) in 1989, and Larry Rahn (Sandia National Laboratories) in 1991.

ORGANIZATION

The 1993 Conference was chaired by Dr. Kermit C. Smyth of the National Institute for Standards and Technology, Gaithersburg, Maryland with Dr. Jean-Pierre Taran of the ONERA Laboratory, Palaiseau, France serving as the vice-chairman. The conference consisted of nine plenary sessions of invited speakers and four poster sessions. Each plenary session was introduced and led by a different discussion leader and included three (morning session) or two (evening session) speakers. The conference program is included on pp. 8-9, and the poster contributions are listed beginning on page 10.

The speakers were asked to introduce their topic and focus on significant diagnostic issues in current research during their 35-minute presentation. Session leaders introduced the speakers and managed the 25-minute discussion period following each talk. The participation during these discussions was excellent; questions and comments easily lasted 25-30 minutes for every presentation. Each poster session included 21 or 22 posters and was held during the hour preceding dinner and continued after the evening session. Refreshments were again provided by the conference chair and vice-chair with funding from interested industrial companies. The poster sessions were well attended and often lasted past midnight. Due to the high quality of the posters and the enthusiasm of the presenters, they were the focus of considerable informal discussion.

The conference was over subscribed for the third consecutive time, with the number of applicants being 157 in 1989, 184 in 1991, and 168 this year. We were able exceed the recommended limit of 135 set by the Gordon Research Directors to a total of 142. The institutions represented by conferees were distributed among academic (57%), government (31%) and industry (12%). While most of the conferees classified themselves as either research scientists (36%) or university professors (25%), a large number of graduate students (27 or 19%) and postdoctoral researchers (19 or 13%) were also present. The remaining conferees included research directors and one program manager. A large fraction (27%) of the conferees were from outside the U.S., representing 10 countries. The list of conference attendees begins on page 16.

TECHNICAL PROGRAM

The technical program concentrated upon underlying basic issues, quantitative measurements, new approaches, and the application of laser diagnostics to a wide range of challenging environments. The opening sessions were devoted to the fundamental physics of diagnostic methods in both gas phase and condensed phase studies. Wave-mixing processes and the quantitative determination of temperatures and species concentrations were emphasized for the gas phase investigations. For the first time talks on droplets and particles were highlighted early in the conference, with discussion centering on issues related to droplet optics, properties within droplets, and particle measurement strategies.

Degenerate four-wave mixing experiments have generated great interest within the diagnostic community, with the result that several talks were included to explore the effects of quenching collisions, thermal gs, beam polarization, and shot-to-shot variations of the laser beam properties. In addition,

the prospects for two-dimensional imaging were described. A second growing area involves measurements with infrared radiation; this topic was first described two years ago. New results were presented on experiments carried out in sooting diffusion flames and under supercritical combustion conditions.

Optical probes of chemistry-turbulence interactions have received increasing attention in recent years. The presentations in this area described the required time and length scales, the accuracy of measured scalar dissipation rates, and strategies for the imaging of mixture fraction. A new session on the modelling of the detailed chemical structure of premixed and diffusion flames was included for the first time this year. Discussion focused on how to obtain meaningful comparisons and which chemical intermediates are the most worthy for experimental study. This session nicely complemented the preceding talks on chemistry-turbulence interactions, since a key question involves how well laminar flames represent turbulent combustion conditions.

A number of diagnostic approaches have been successfully applied in practical devices, including internal combustion engines. This year new developments using rotational CARS, temperature imaging, and emission spectroscopy were presented. Issues discussed included pressure uncertainties, needs for quantitative data, and future requirements. Fast flows also present difficult diagnostic challenges. Temperature uncertainties, measurements in large scale facilities, and systematic errors involved in laser-induced fluorescence experiments were described in detail. Finally, our program included presentations on superequilibrium OH concentrations in combusting spray flames and a new look at the possibilities for picosecond measurements in turbulent flow fields and at elevated pressures.

In conclusion, many fundamental questions remain for the application of laser diagnostics to combustion environments, including the prediction of spectra at high densities, the viability of resonant DFWM in complex flow fields, and the effect on quantitative interpretation of results due to optical pumping, collisional effects, and measurements in multi-phase flows. Despite significant progress, the continuing needs for higher combustion efficiencies and lower pollutant levels present substantial challenges for researchers. The laser diagnostic field remains vigorous and expanding, and this Gordon Conference continues to provide an excellent forum in which laser diagnosticians and combustion modelers can share their thoughts, results, and concerns.

FUTURE CONFERENCE

On Wednesday evening the conference elected Prof. Marshall Long (Yale University) as the new vice-chairman. At the business meeting conducted by Dr. Jean-Pierre Taran (ONERA Laboratory, Palaiseau, France; 1995 chairman) it was unanimously agreed to hold the conference again in 1995, requesting the week of July 17-21 at Plymouth State College, Plymouth, New Hampshire. In addition, the possibility of holding the next conference in Europe was discussed, with generally favorable comments (costs and our ability to raise additional funds were the main perceived difficulties). Arrangements for a 1995 Gordon Research Conference on Laser Diagnostics in Europe will be explored by Jean-Pierre Taran. It was agreed that this conference unambiguously meets the objectives of the Gordon Research Conferences, i.e., to discuss topics at the forefront of research and to fulfil a need that is not provided by other national and international conferences and workshops. The conference evaluations from the participants were very positive, indicating the excellent character of the conference.

FUNDING SOURCES FOR CONFERENCE FEES AND TRAVEL

Gordon Research Conferences Special Fund		$15,000
DOE Morgantown Energy Technology Center		5,000
Gas Research Institute		6,000
National Science Foundation		5,000
NASA Langley Research Center		2,500
Office of Naval Research		5,000
Carryover from 1991 meeting		1,443
	Total	$39,943

EXPENDITURES FOR CONFERENCE FEES AND TRAVEL

Speakers and Discussion Leaders		
15 U.S.		$10,190
9 Foreign		8,264
Graduate Students and Post Docs		
16 U.S.		7,172
9 Foreign		5,240
Other Conferees		
9 U.S.		4,154
3 Foreign		1,540
61 Persons Supported	Total	$36,560

MISCELLANEOUS FUNDING SOURCES AND EXPENDITURES

Gordon Research Conferences Chairman's fund for administrative costs	$600
<u>Refreshments at Poster Sessions</u>	
Lambda Physik	300
Lightwave Electronics	300
NESLAB	300
Spectra Physics	300
Total Expenses	$1,458
Carryover	$342
Grand Total Carryover	$3,725

1993 Gordon Research Conference on the Physics and Chemistry of Laser Diagnostics in Combustion

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MONDAY, July 12

9:00 AM Welcome - Kermit Smyth

1. Fundamental Issues - Gas Phase
   - 9:10 Discussion Leader: Douglas Greenhalgh (Cranfield)
   - 9:15 Jean-Pierre Taran (ONERA) - *CARS: New Approaches and Perspectives For the Future*
   - 10:10 Break and Picture Session
   - 10:40 Larry Rahn (Sandia) - *Nearly Degenerate Four-Wave Mixing Measurements of Population Lifetimes*
   - 11:35 Katharina Kohse-Höinghaus (DLR, Stuttgart) - *The Dynamic OH Model for Concentration and Temperature Measurements*

12:30 PM Lunch
5:00 Poster Session I
6:00 Dinner

2. Fundamental Issues - Condensed Phases
   - 7:30 Discussion Leader: Richard Chang (Yale)
   - 7:35 Michael Winter (UTRC) - *Diagnostic Measurements of Fundamental Processes in Droplets*
   - 8:35 Robert Santoro (Penn State) - *Particle Size Measurements: From Spheres to Aggregates*
   - 9:35 Refreshments at Posters.

TUESDAY, July 13

9:00 AM Announcements

3. Resonant Wave-Mixing
   - 9:10 Discussion Leader: Jay Jeffries (SRI)
   - 9:15 Roger Farrow (Sandia) - *Effects of Quenching and Thermal Gratings in Degenerate Four-Wave Mixing*
   - 10:15 Break
   - 10:30 Skip Williams (Stanford) - *DFWM Measurements of CH· in Flames and Plasmas*
   - 11:30 Paul Ewart (Oxford) - *Imaging and Temperature Measurement of Flames by DFWM*

12:30 PM Lunch
5:00 Poster Session II
6:00 Dinner

4. Diagnostics in the Infrared
   - 7:30 Discussion Leader: Gregory Rosasco (NIST)
   - 7:35 Houston Miller (George Washington) - *Quantitative Tunable Diode Laser Measurements of Concentrations and Temperature in Hydrocarbon Diffusion Flames*
   - 8:35 Thomas Brill (Delaware) - *Spectroscopy of Chemical Reactions in Supercritical Water*
   - 9:35 Refreshments at Posters.

WEDNESDAY, July 14

9:00 Nominating Committee Report

5. Chemistry-Turbulence Interactions

9:10 Discussion Leader: Robert Dibble (Berkeley)

9:15 James Driscoll (Michigan) - *Diagnostic Challenges to Understanding Flame-Vortex Interactions*

10:15 Break

10:30 Robert Pitz (Vanderbilt) - *UV Raman Measurement of Reaction Zones: The Chemistry/Scalar Dissipation Rate Interaction*

11:30 Marshall Long (Yale) - *Mixture Fraction Imaging in Turbulent Non-Premixed Flames*

12:30 PM Lunch

5:00 Poster Session III

6:00 Dinner

6. The Modeler's View

7:30 Discussion Leader: Kermit Smyth (NIST)

7:35 Gregory Smith (SRI) - *Kinetic Meaning of Diagnostic Measurements in Premixed Flames*

8:35 Peter Lindstedt (Imperial College) - *Role of Laser Diagnostics in the Development of Detailed Kinetics for Hydrocarbon Diffusion Flames*

9:35 Refreshments at Posters.

THURSDAY, July 15

9:00 AM Announcements

7. Diagnostics in Nasty Environments

9:10 Discussion Leader: Jürgen Wolfrum (Heidelberg)

9:15 Per-Erik Bengtsson (Lund) - *Development and Applications of Rotational CARS*

10:15 Break

10:30 Volker Sick (Heidelberg) - *Simultaneous LIF Temperature and Concentration Measurements in Practical Device*

11:30 Michael Drake and Todd Fansler (GM) - *High-Speed Visualization of Fuel Sprays and Combustion in Engines*

12:30 PM Lunch

5:00 Poster Session IV

6:00 Dinner

8. Diagnostics in Fast Flows

7:30 Discussion Leader: Richard Miles (Princeton)

7:35 Brian McMillan (Stanford) - *Two-Line, Instantaneous Temperature and Velocity Imaging in Supersonic Mixing and Combusting Flows*

8:35 Gabriel Laufer (Virginia) - *LIF Measurements in a H_2/Air Supersonic Combustion Tunnel*

9:35 Refreshments at Posters.

FRIDAY, July 16

9. Challenging Applications

9:00 Discussion Leader: Phillip Paul (Sandia)

9:05 Denis Stepowski (Rouen) - *Investigation of Liquid, Vaporized, and Reacting Species in a Burning Spray by Planar Raman and Fluorescence Techniques*

10:05 Break

10:15 Gregory Fiechtner (Colorado) - *Picosecond Pump-Probe Absorption Spectroscopy for Species Concentration Measurements in Turbulent Flames*

11:15 Open discussion of future directions for the Conference.

11:35 Adjourn to Lunch and Buses

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** POSTER SCHEDULE **

Session I
Monday July 12

1 Determination of Alkali Traces in Coal Combustion by Excimer Laser Induced Fluorescence
T. Hartinger, P. Monkhouse and J.Wolfrum

2 Quantitative Detection of Hydrocarbons and Chlorinated Hydrocarbons using VUV-Photoionization
L.D. Pfefferle

3 Saturation Effects in Gas-Phase Degenerate Four-Wave Mixing Spectroscopy: Nonperturbative Calculations
Robert P. Lucht, Roger L. Farrow and David J. Rakestraw

4 Color Image Processing and Analysis of Reactive Spray Experiments
Michael J. McQuaid and Avi Rirk

5 Neural Networks Fitting CARS Spectra
D. Dunn-Rankin and R.D. Jones

6 Spectral Determination of Interaction Droplets Evaporation Rate, Shape Distortions and Drag Coefficient
Gang Chen and Richard K. Chang

7 2D Imaging of Soot in Flames by Laser Induced Incandescence
F. Cignoli, S. Benecchi and G. Zizak

8 Flame Measurements Using Picosecond Time-resolved Laser-Induced Fluorescence
Michael Klasser, Thomas Reichardt, Galen King and Normand Laurendeau

9 A 60 Picosecond Excimer-Raman Laser in the Ultraviolet
Michael D. Burrows

10 Comparison of Vibrational and Pure Rotational CARS for Combustion Diagnostics
T. Seeger, H. Spiegel, A. Thuymann and A. Leipertz

11 Energy Transfer in OH $A^2\Sigma^+$ and its Influence on Quantitative LIF Measurements
M.P. Lee, R. Kienle and K. Kohse-Höinghaus

12 Applications of Two-Photon LIF for Two-Dimensional Measurements of Combustion Species
N. Georgiev, H. Neij and M. Aldén

13 Determination of Temperature Fields following CO_2-Laser Induced Ignition of CH_3 OH/O_2 Mixtures
T. Heitzmann and Jürgen Wolfrum

14 Two-Photon Excitation of Atomic Oxygen Using a Raman-Shifted, ArF Excimer Laser
D.G. Fletcher

15 What measures Soot in Flames? Laser Extinction, Scattering and Fluorescence Imaging of the Soot Region of Time-Varying and Steady-State Methane/Air Flames
Joel E. Harrington, Christopher R. Shaddix and Kermit C. Smyth

16 Effects of Finite Beam Width on Elastic Light Scattering from Droplets
J.T. Hodges and C. Presser

17 Flow Tagging in Water Using Photo-Activated Fluorophores
Walter R. Lempert, R.B. Miles, K. Magee, K.R. Gee and R.P. Haughland

18 A Picosecond Pump/Probe Absorption Model for Quantitative Concentration Measurements in Turbulent, High-Pressure Flames
G.J. Fiechtner, N.M. Laurendeau and G.R. King

19 Collisional Energy Transfer in Predissociative OH LIF in Flames
Kristen L. Steffens, Jay B. Jeffries, David R. Crosley

20 "Precession of Cavity Resonances in Slightly Non-Spherical Droplets
J.Christian Swindal, David H. Leach and Richard K. Chang

21 "Planar Imaging of the Soot Field in Turbulent Diffusion Flames by Laser Induced Incandescence"
N.P. Tait and D.A. Greenhalgh

Session II
Tuesday July 13

1 Time- and Spatially Resolved LIF of OH $A^2\Sigma^+(v'=1)$ in Atmospheric Pressure Flames using Picosecond Excitation
A. Dreizler, R. Tadday, P. Monkouse and J. Wolfrum

2 Rotational Temperature Measurement in Reacting Flows Using KrF Laser-Induced O_2 Fluorescence
Jay. H. Grinstead, Gabriel Laufer and J. C. McDaniel, Jr.

3 Detection of Polyatomic Molecules Using Infrared Degenerate Four-Wave Mixing
Geoffrey J. Germann, Andrew McIlroy, Roger Farrow and David Rakestraw

4 Combustion Species Imaging in an Optically Accessible Internal Combustion Engine
[illegible]i Serpengüzel, Robert T. Hahn and William P. Acker

5 Quantitative Detection of Flame Radicals and Neutrals by Diode Laser Wavelength Modulation Spectroscopy
Daniel B. Oh, Alan C. Stanton, David C. Hovde, David S. Bomse and Joel A. Silver

6 Two Degenerate Four-Wave Mixing Techniques for Measurement of OH in Flat Flames at 1 to 9 Bar Compared with Laser-Induced Fluorescence and Absorption Measurements
Eric Domingues, Marie-Joseph Cottereau and Douglas Feikema

7 Imaging of Flame Structures by Degenerate Four-Wave Mixing
A. Koch, P.G.R. Smith, R. Williams and P. Ewart

8 Application of Laser-Induced Gratings for Diagnostics Purposes
B. Hemmerling and A. Stampanoni

9 Applications of Fluorescent Lifetime Imaging
T. Q. Ni and Lynn A. Melton

10 Nearly Degenerate Four-Wave Mixing Velocity Diagnostic
Paul M. Danehy

11 Resonance Holographic Interferometric Spectroscopy (RHIS)
Peter A. DeBarber, James D. Trolinger and Cecil F. Hess

12 Diagnostic Development of DFWM and Polarization Spectroscopy for Combustion Studies
R. Fritzon, N. Georgiev, K. Nyholm and M. Aldén

13 Multi-Point Measurement of Temperature and Species Concentrations in Opposed Jet Flames by UV Raman Scattering
T.M. Brown, S.P. Nandula, P.A. Skaggs and R. W. Pitz

14 Spectroscopy with Widely Tunable Diode Lasers
Philip Varghese and Reynaldo Villarreal

15 Efficient Vibrational Raman Conversion in N_2 and O_2 Cells Using Super-Fluorescence Seeding
B. Zhang, W.R. Lempert, R.B.Miles and G. Diskin

16 Laser-Induced Fluorescence Studies of OH, NO and CH in Low Pressure Propane/Air Flames
Ulf Westblom, Gregory P. Smith, David R. Crosley, and Jay B. Jeffries

17 Laser-Excited Amplified Spontaneous Emission
Michael S. Brown and Jay B. Jeffries

18 Potential Ultrashort-Laser-Pulse Combustion Diagnostics? 1) Extra Resonances in the Time Domain and 2) 3D Mapping of a Medium
Rick Trebino

19 Rayleigh and Predissociative Fluorescence Imaging, of Total and of Quantum State-Specific Densities from a Combustion Bomb and from a Sandia Engine Using Tunable Excimer Laser Light
Hon An, Erhard W. Rothe, and Lynne M. Hitchcock

20 DFWM Imaging of Combustion Species in a Burner
Berenice A. Mann

21 Accurate Calculations of Rotational Line Intensities in the DFWM Spectrum of NO
E.J. Fiedmann-Hill, Larry A. Rahn and Roger L. Farrow

22 Thermal Gratings ; OH and NO Quenching
P. Paul ; J. Gray and J. Durant

Session III
Wednesday July 14

1 Flame Lift-off Investigation above an Air-Blast Injector by Phase-Doppler and OH Fluorescence Measurements
A. Cessou and D. Stepowski

2 Quantitative 2D-Mixture Fraction Imaging Inside An Internal Combustion Engine Using Aceton-Fluorescence
H. Schlüter, D. Wolff and V. Beushausen

3 PLIF imaging of Nitric Oxide Formation in Inverse Diffusion Flames
W.P. Partridge, Jr. and Normand M. Laurendeau

4 Measurements of NO, OH and the Major Species in Turbulent Flames
Campbell D. Carter and Robert S. Barlow

5 Temporal Scale Measurements of Number Density Fluctuations in the Shear Layer of Free and Acoustically-Driven Axisymmetric Jets Using a Two-Pulsed Laser Scheme
P.P. Yaney, D.A. Steck and J.W. Parish

6 Simultaneous CARS and 2D Rayleigh Temperature Measurements in a Turbulent Industrial Swirl Combustor
S. Kampmann, T. Seeger, and A. Leipertz

7 Combustion Characteristics of a Burner that Simulates a Jet Engine Combustor
Paul O. Hedman, David L. Warren, David K. Pyper, Larry Goss, Darrel Trump, Benjamin Sarka, K. Y. Hsu and W. M. Roquemore

8 Periodic Vortex-Flame Interactions in a Diffusion Flame
K.Y. Hsu and L.P. Goss

9 Multi-Dimensional Temperature-, OH-Concentration and Velocity Fields in Turbulent Premixed Flames
A. Buschmann, F. Dinkelacker, M. Schäfer and Jürgen Wolfrum

10 Measurement of Sound Speed, Thermal Diffusivity, and Viscosity via Time-Resolved FWM off Laser-Induced Hydrodynamic Modes
Eric B. Cummings

11 Multi-Species Line Raman Measurement in H_2-Air Turbulent Diffusion Flames
S.P. Nandula, T.M. Brown, P.A. Skaggs and R.W. Pitz

12 Characterization of Differential Molecular Diffusion and Turbulent Transport by Rayleigh and Fluorescence Imaging
Kevin M. Lyons, Jonathan H. Frank and Marshall B. Long

13 Spatial and Temporal Characterization of the Scalar Field in Turbulent Premixed Flames by Laser Induced Rayleigh Scattering
I. Gökalp

14 Images of the Quenching of a Flame by a Vortex - To Quantify Regimes of Turbulent Combustion
William L. Roberts, James F. Driscoll, Michael C. Drake and Larry P. Goss

15 Laser-Induced Fluorescence Studies of MnO in Atmospheric Pressure Flames
Ulf Westblom, Gregory P. Smith, David R. Crosley, and Jay B. Jeffries

16 Optical Diagnostics of Diamond CVD in DC-Arc-Jet Plasmas
Michael S. Brown, George A. Raiche, Jay B. Jeffries, Douglas Beattie and Mark A. Cappelli

17 Experiments Concerning Rempi Probe Measurements of Flame Species Profiles
Asa Fein, Jeffrey S. Bernstein, Xiao-Mei Song and Terril A. Cool

18 "The Structure of Scalar Dissipation Sheet for Sc = 1"
K.A. Buch and P.H. Paul

19 "Investigation of H_2 -air opposed Jet Flames Using Raman Scattering"
C-S. Pai, S. Yeralan, and J. A. Wehrmeyer

20 "Double Pulse 2DLIF as a Means for Following Flow and Chemistry Development in Turbulent Combustion"
B. Atakan, V. Jörres and K. Kohse-Höinghaus

21 "PLIF Imaging of OH Radicals to Estimate Local Mass Burning Rates in Turbulent Premixed Methane-Air Flames"
N. Farrugia and D.A. Greenhalgh

Session IV
Thursday July 15

1 Vaporization Dynamics in a Burning Spray by Planar Raman and Fluorescence Spectroscopies
R. Bazile and D. Stepowski

2 Simultaneous Spatially Resolved Multi-Species and Temperature Analysis in a Four-Cylinder In-Line Engine and in a Spray Flame Using Linear Raman Scattering
G. Gruenefeld, H. Schlueter, V. Beushausen and P. Andresen.

3 Diode Laser Tomography of Microgravity Diffusion Jet Flames
Joel A. Silver and Daniel J. Kane

4 Laser Induced Fluorescence and Degenerate Four-Wave Mixing Measurements of NO in a 100,000 Btu/Hr Atmospheric Pressure Natural Gas Burner
J. D. Garman, D. Dunn-Rankin, R. Farrow and D. Rakestraw

5 Spatially Resolved Velocity Measurements in Steady High-Speed Reacting Flows
K. G. Klavuhn, G. Gauba and J. C. McDaniel

6 Simultaneous, Multiple Camera Fluorescence Imaging: Application to High Speed, Reacting Flows
J.M. Seitzman, B.K. Mc Millin, M.F. Miller and R.K. Hanson

7 Laser Induced Breakdown Spectra in a Coal-Fired Combustion Environment
H. Zhang, Jagdish P. Singh, Fang-Yu Yueh and Robert L. Cook

8 Laser-Induced Fluorescence Measurements of Nitric Oxide in Laminar High Pressure Flames
John R. Reisel and Normand M. Laurendeau

9 Stable and efficient SRS-based Radiation Sources Designed for Use in Laser Diagnostics
V.A. Orlovich, D.E. Gakhovich, A. S. Grabchikov, S.S Dvornikov, S.G. Kruglik, and V.V. Kvach

10 A 30 Hz CARS System for the Measurement of the Concentrations of Nitrogen, Water, and Hydrogen, and Nitrogen Temperature
M.W. Smith, A.D. Cutler, M.W. Millard, O. Jarrett and G.B. Northam

11 Raman Studies of CH_3CCl_3 and CH_2Cl_2 for SCWO Applications
Wilbur S. Hurst

12 Exciplex Thermometry and Tunable Diode Laser Diagnostics in Microgravity Combustion Science
Randall L. Vander Wal, Karen J. Weiland, Paul S. Greenberg and DeVon W. Griffin

13 Wavelength Modulation Absorption Spectroscopy for Multi-Parameter Gasdynamic Measurements
R.K. Hanson, M. DiRosa, P. Arroyo and L. Philippe

14 Doppler-Shifted OH Velocity Imaging in Supersonic, Combusting Gases
M.G. Allen, S.J. Davis, H.H. Legner, K.R. McManus, P.A Mulhall and T.E. Parker

15 Flowfield Measurements in a Rocket Chamber
R.J. Santoro, S. Pal and D. Moser

16 Flow Visualization and Parameter Measurements of Supersonic Flows Using Double Pulse Rayleigh and Filtered Rayleigh Scattering
J. Forkey, W. Lempert and R. Miles

17 Quantitative Concentrations Measurements of Atomic Potassium in Atmospheric Flames Using a Regeneratively Mode-Locked Ti:Sapphire Laser
G. J. Fiechtner and M.A. Linne

18 Nitric Oxide CARS Spectrocopy in Propellant Flames
Alfred Kurtz

19 Detection of Radicals in Chlorinated Hydrocarbon and Organophosphate Laminar Flames
Sunita Satyapal and Terril A. Cool

20 "Studies of Surface Deactivation of Vibrationnallly Excited Homonuclear Diatomic Molecules Using 3D-Folded BOXCARS"
P.P. Yaney and R. Rimkus

21 "C.A.R.S. Temperature Measurements in a High Pressure Combustion Environment using Experimental Spectra from a Calibrated High-pressure High Temperature Optical Cell"
D. Ball, R.J. Hutcheon, R.D. Lockett, G.N. Robertson

GORDON RESEARCH CONFERENCES
LASER DIAGNOSTICS IN COMBUSTION
Plymouth State College
July 11 - 16, 1993
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